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RELATED DISTRIBUTION PATTERNS IN SOILS AND THEIR SIGNIFICANCE

by

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RESUMEN

MODELOS DE DISTRIBUCION RELACIONADA EN SUELOS Y SU SIGNIFICADO

Los modelos de distribución relacionada son parámetros micromorfológicos de gran importancia en los estudios edafogenéticos. Se consideran dos grupos: uno constituido por *modelos de distribución relacionada normal* (básica), y otro por *modelos de distribución relacionada específica*, dependiendo de la función del plasma. Dentro de cada grupo se han determinado varios tipos, definiéndose cada uno de ellos. Se establece, en diagrama triangular, la correlación entre granulometría y distribución relacionada básica (normal. «NRDP»). Se presentan ejemplos de suelos donde ocurren ambos grupos, ilustrándose algunos de ellos.

INTRODUCTION

The concept of the related distribution pattern (RDP) in Soil Micromorphology was introduced by Brewer (1964) who considered it as the «distribution pattern of like individuals with regard to the distribution of individuals of a different kind». In this concept both the ratio of plasma to skeleton grains (e. g. granular and porphyroskelic) and specific arrangement patterns of the plasma with respect to the skeleton grains (e. g. agglomeroplasmic and intertextic) are considered, following Kubiëna (1938). Since the contribution of Brewer, more RDP's are recognised, e. g. phyric (Eswaran et al., 1969) and argillamatric (Eswaran, 1972; Bellinfante et al., 1974). These latter ad hoc suggestions are the result of the study of a wider range of soil materials. Reviewing the situation, the authors felt the need for a more systematic terminology and this forms the objetive of this paper.

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Stoops et al. (1974), confronted with a similar situation proposed the «c/f related distribution» and defined it as «the c/f related distribution expresses the distribution of individuals particles with relation to finer material and associated voids not included in the particles». In this concept, size limits of the particles is left to decision of the user.

The concepts and terminology developed here are purely for pedological purposes and not for other uses of the Micromorphological techniques as envisaged by Stoops et al. (1974). It is the intention here to relate micromorphological properties of the soil to the pedological properties. Related distribution patterns are one of the micromorphological parameters that can be employed to evaluate soils and soil genesis.

Concepts

The pedon (USDA, 1974) is the smallest volume that is recognised as soil individual. The vertical section of the pedon is the soil profile which is composed of horizons. A thin-section is a sample of a horizon. The basic descriptive unit is the s-matrix which is «the material within the simplest (primary) peds, or composing apedal soil materials, in which the pedological features occur; it consists of the plasma, skeleton grains and voids that do not occur in pedological features other than plasma separations» (Brewer, 1964).

The plasma, grains and voids are the three basic components of the s-matrix. The pedological features are a result of a specific combination or arrangement of one or more of the components. The concept of the plasma and grains differ from that of Brewer's and so is given in detail.

The plasma

The plasma is the colloidal fraction of the soil which may be mineral or organic. This is the most active component of the soil material and is capable of reorganisation, translocation and neoformation. In Soil Taxonomy, soils are classified based on the activity of the plasma or on the characteristics given to the soil by a specific behavior of the plasma. The oxic horizon is one where the chemical activity is low (type of plasma); in the argillic horizon plasma has accumulated by translocation; in the albic horizon plasma has been removed and in the spodic horizon a specific kind of plasma is accumulated. These diagnostic horizons characterise certain groups of soils. So in the choice of parameters for micromorphological indicators of pedogenesis (Eswaran, 1972) study on plasma has important bearing.

Although a colloidal size is specified, individual plasma cannot be seen with the petrographic microscope and even with the scanning electron microscope (SEM) a magnification of more than 10,000 is generally necessary. However, plasma domains are readily discernable. Presence or absence of domains and the size and arrangement of domains are important micromorphological characteristics which will be evaluated in a later contribution.

The grain

The grain is a single particle greater than colloidal size. Fragments of plant remains larger than colloidal size are frequently present in soils especially in the surface horizons. These are recognisable entities and are described as such. Consequently grains will only include the mineral materials.

Grains comprise a range of minerals which are primary or secondary, which vary in solubility, which are or may be present in all stages of transformation and which are present in all size grades. A classification of grains based on these parameters will be useful and may be made when necessary but will not add any additional information than simple descriptive terms. For example, gypsum relative to quartz is a soluble mineral and so a subdivision into soluble and non-soluble minerals or restricting the grains to their resistent properties is an attractive proposition. However, in the context of the Aridisols, where gypsum is most frequent, it is a stable mineral and so the division looses its relevance.

For these reasons the classification of grains is reduced to a minimum. This will not preclude the use of comparative or descriptive terms based on interpretation neoformed quartz, biotite pseudomorph, plasmified feldspar or secondary gypsum. One useful division of grains is into sand and silt size, the limit being 50 microns. This division is petrographically possible and will correspond to textural analysis.

The voids

The voids are empty spaces in thin-sections. A few may be artifacts caused by the preparation of the thin-section. Others show some regularity of shape and configuration that they can be grouped together. Brewer's nomenclature of voids is adhered to.

Related distribution patterns

The components of direct interest here are the plasma and grains: voids being a consequence of the arrangement of the other components.

The two basic aspects of RDP are the proportions of plasma, silt and sand in the s-matrix, and the specific arrangement of the plasma with respect to the other two. The arrangement does not lead to formation of distinct entities in which case they are pedological features. However, the arrangement gives a specific aspect to the s-matrix.

What is the cause of the arrangement patterns? In most cases this is due to pedogenesis: some sedimentary features can also attain such forms. In the absence of pedogenetic influence, there is a random distribution of the plasma, silt and sand; random in the sense that the plasma does not play any specific role in the arrangement of the silt and sand. This is considered as the normal-basic situation and the RDP is termed the Normal Basic Related Distribution Pattern (NRDP). The NRDP does not exclude such features as banded or clustered arrangement of the silt and sand grains as in some sediments. With pedogenesis, the plasma attains a different role. It bridges or coats grains, it aggregates silt and sand or it forms clusters. What the plasma does depends on the type of plasma, the NRDP and the formation stage of the soil. One will argue that this is a genetic división. It is genetic but the resulting micromorphological features are distinct enough to group them as Specific Related Distribution Patterns (SRDP). They are in fact extragrades to NRDP.

The normal related distribution patterns

The NRDP's are differentiated on the proportion of plasma to sand to silt. The textural triangle (USDA) is employed for this purpose. This diagram, fig. 1, attempts to relate the texture of the soil to micromorphology.

Granic

Granic NRDP is characterised by a dominance of sand-sized particles with small amounts of plasma and silt. The associated voids are those resulting from a close packing of sand grains — intergranular voids or simple packing voids. The field textures are commonly sands and loamy sands.

This is a typical related distribution pattern of the albic horizon in some Alfisols and in Psamments. When necessary the name of the mineral is used as a prefix. e. g. A Psamment has a quartzi-granic NRDP; some gypsic horizons have a gypsi-granic NRDP.

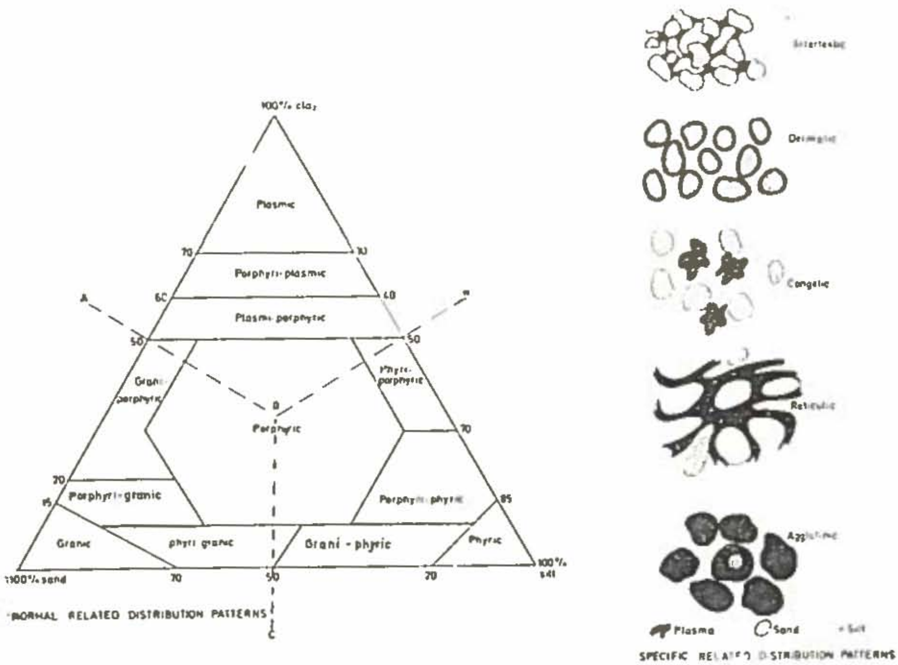

Fig. 1.—Normal (basic) and specific related distribution in soils.

Phyric

Phyric NRDP is characterised by a dominance of silt-sized grains with small amounts of plasma and sand. This is a much closer packing than granic; the voids are also intergranular. The field texture is silty and the consistence is compact and firm.

The albic horizon of some fine textured podsols (Eswaran et al., 1969) typify this NRDP. Sediments composed of silt have this NRDP. Some calcic horizons or calcareous soil materials have a calci-phyric NRDP. Some gibbsic horizons have a gibbsi-phyric NRDP (Plate 1, c).

Plasmic

Plasmic NRDP is characterised by a dominance of plasma with small amounts of silt and sand. Voids that are present include vughs, channels, vesicles and planes. The field texture is heavy clay and this NRDP characterises clayey sediments and highly weathered soils on basic and ultrabasic rocks — Ultisols and Oxisols (Plate 1, a).

This term supercedes the original term — argillamatric — of Eswaran (1972).

Porphyric

Phorphyric NRDP is characterised by an balanced amount of plasma, silt and sand. This NRDP grades to plasmic, phyric or granic when the amount of one of the component exceeds the sum of the other two. The sand frequently appears more prominent and is generally embedded in the s-matrix. A clay loam and loam texture characterise this NRDP. All types of voids may be present.

Intergrades

As shown in fig. 1, eight intergrades are recognised. These are characterised by the dominance of one component over the other. The intergrades are:

1. Phorphyri-plasmic.
2. Plasmi-porphyric.
3. Phyri-porphyric.
4. Porphyri-phyric.
5. Grani-porphyric.
6. Porphyri-granic.
7. Phyri-granic.
8. Grani-phyric.

PLATE 1

a) *Plasmic* normal related distribution pattern. Dominance of plasma without tendency to aggregate is the characteristic feature. Oxisols with agglutinic SRDP in the upper part of the profile have a plasmic NRDP in the lower.

b) *Agglutinic* specific related distribution pattern. The soil is an Acrorthox. It is a highly weathered soil and the plasma is dominantly sesquioxides with some kaolinite. Grains are few. Aggregation of the plasma to give a highly porous material is a comun feature.

c) *Phyric* normal related distribution pattern. The soil is a Gibbsiorthox. Silt-sized grains of gibbsite form the s-matrix of the gibbsic horizon. There is little or no plasma. The RDP is infact gibbsi-phyric.

d) *Congelic* specific related distribution pattern. The soil is a Andept. The plasmic clusters are distributed randomly between the grains.

(The white bar on the photos has a length of 0.02 mm.)

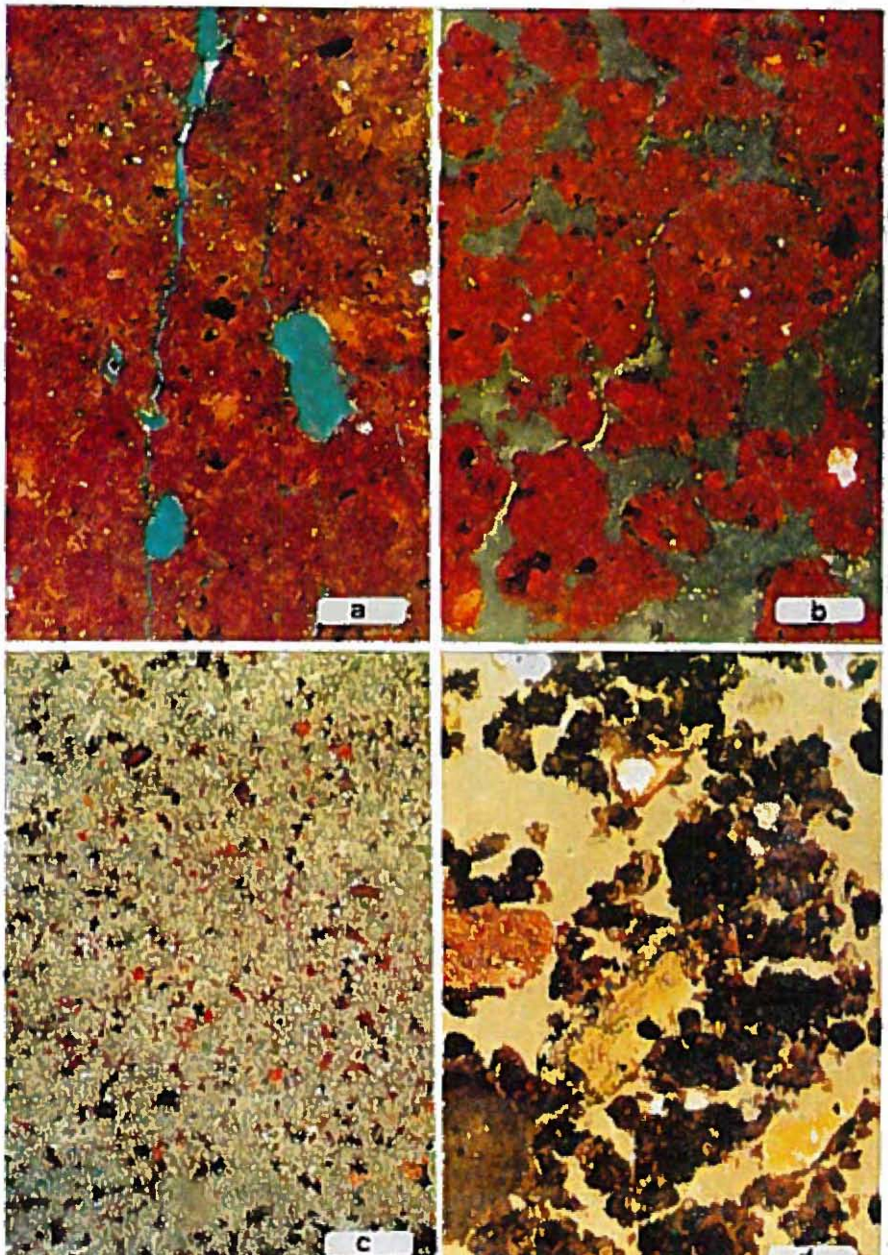

PLATE 1

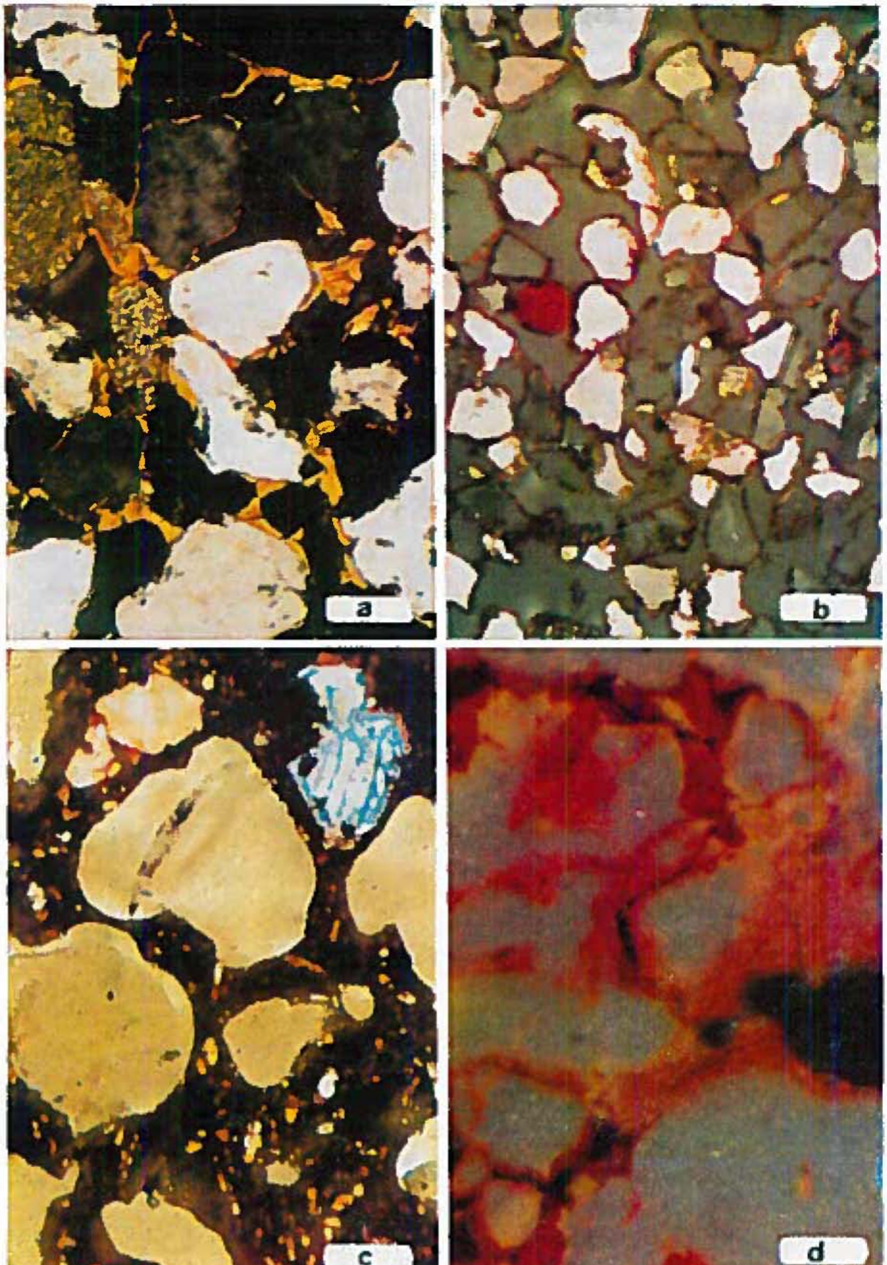

PLATE 2

a) *Intertextic* specific related distribution pattern. This is a typical feature of the argillic horizon on sands. The translocated plasma forms bridges between the grains.

b) *Dermatic* specific related distribution pattern. The spodic horizon in sands shows this. The translocated plasma coats the grains.

c and d) *Reticulic* specific related distribution pattern. Two types are shown. c) is an instance where a vesicular basalt is plasmified without volume changes.

In d), the sesquioxidic plasma attains a reticulic pattern in a plasmic kaolinite mass. This is the normal morphology of plinthite.

(The white bar on the photos has a lenght of 0.02 mm.)

A second group of intergrades are those where a single s-matrix shows more than one NRDP. For these combinations, the most dominant is indicated last:

> «a granic and porphyric» NRDP characterises a s-matrix which is dominantly porphyric but where there are patches of granic.

The texture of the soil as determined by granulometric analysis, gives a first idea of the NRDP. The actual NRDP may not exactly coincide due to localised differentiation in the s-matrix — presence of intergrades — or due to pedogenesis which gives rise to the SRDPs.

Specific related distribution patterns

Due to the properties of the plasma, consequent to pedogenesis, specific related distribution patterns result. In Soil Taxonomy (USDA, 1974), soils which are due to special processes which result in specific morphological traits are grouped together. The macromorphological features have their counterparts in thin-sections and SRDPs are one of them.

> Specific related distribution patterns (SRDP) are those which cannot be attributed to the random arrangement of plasma with respect to the silt and sand.

Five SRDPs are recognised for the moment: more will inevitably be added as distinct types are studied.

Intertextic

Intertextic SRDP is one where the plasma forms bridges connecting the sand grains (Brewer ss.). The SRDP is confined to materials with granic NRDP. The field texture is sandy to sandy loam and the consistence is fluffy.

The plasma is generally translocated and this SRDP is usually an early stage of the next type dermatic. The SRDP is present in some spodic and argillic horizons. Many banded textural B horizons on sandy materials show this SRDP (Plate 2, a).

Dermatic

Dermatic SRDP is one where the plasma forms a complete coating around the grains which are usually sand sized (Plate 2, b).

This SRDP is typically associated with sandy materials. In fig. 1, it is confined to the region delimited by AOC and the apex of the triangle but expression becomes indistinct in materials other than granic. For all practical purposes, dermatic is considered to be derived from granic.

The genesis of dermatic SRDP is due to plasma accumulation by translocation in sandy materials. The plasma is both mineral and organic. These transformations are possible in Spodosols and in sandy Alfisols and Ultisols. The micro-pedomorphosis of the s-matrix is examined in greater detail in several soils. Fig. 2, shows the sequence of evolution of the soil and the concomitant changes in the related distribution patterns.

Congelic

Congelic SRDP is one where the plasma aggregates silt-sized materials; the larger grains do not generally participate in the process and so the resulting morphology consists of silt-sized particles aggregated together by plasma and present in between coarser sand-sized particles (Plate 1, d).

The process described above takes place only if the plasma is or was in an amorphous state or has a significant amount of amorphous colloids and the NRDP must be phyric. If only sand and amorphous plasma are present, a dermatic SRDP results. The previous conditions are present in groups of soils such as:

> Spodosols on fine textured materials and in Andosols or Andepts.

The NRDP of the parent materials is generally in the region BOC (fig. 1) but is best expressed in soils with phyric NRDP-intergrades.

In Spodosols on silty parent materials, the translocated amorphous plasma aggregates the silt particles leading to the congelic SRDP. This was studied by Eswaran et al. (1969). In the field, the B_{2ir} horizon which shows this SRDP is spongy and fluffy whilst the overlying A_2 which has a phyri-granic NRDP is compact. Roots of plants pass trough the A_2 and proliferate in the more porous B_{2ir}.

In Andepts, the allophane behaves similarly and the field consistence is similar. The high porosity and rapid internal permeability of these soils or horizons is explained by the formation of the SRDP.

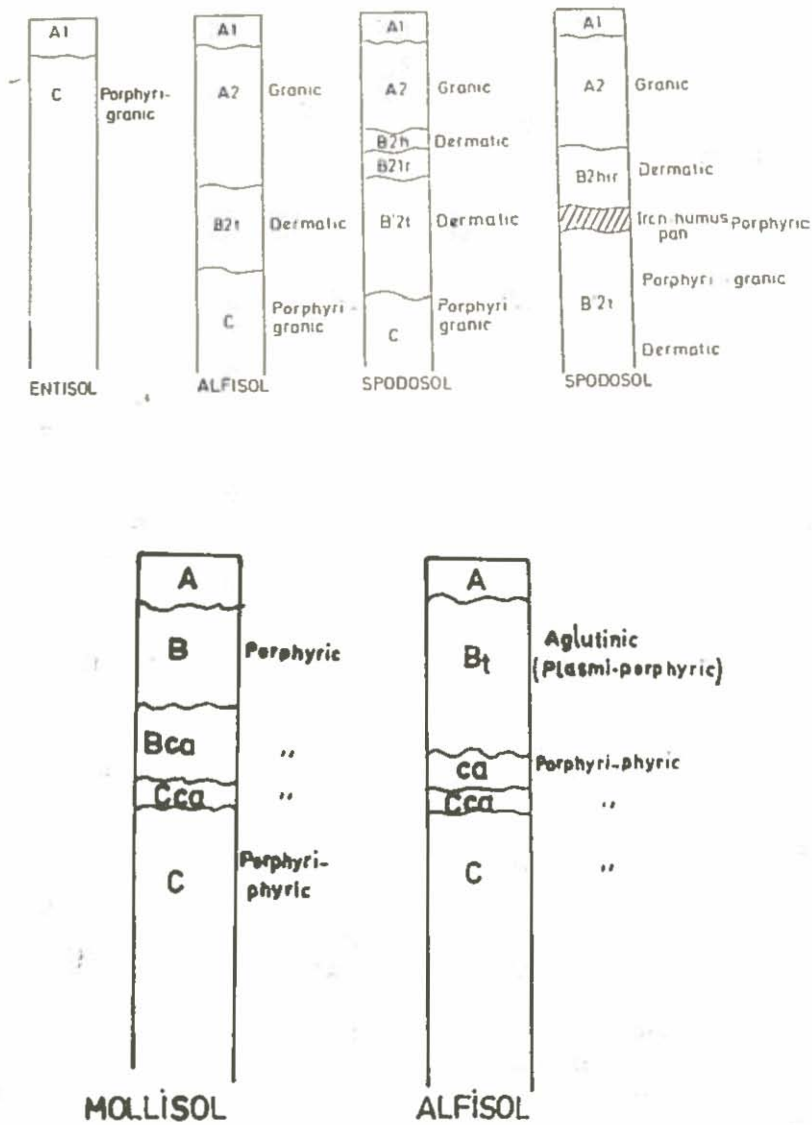

Fig. 2.—Changes in related distribution patterns as a function of evolution of the soils: a) developed on sandy materials. b) Developed on Quaternary calcareus sediments.

Agglutinic

Agglutinic SRDP is one where the plasma is aggregated together into sand or silt sized aggregates incorporating any silt or sand grains (Plate 1, b).

The processes involved are similar to the ones leading to the congelic SRDP; the difference is that they act on plasmic materials. Agglutinic SRDPs have been observed in clayey Oxisols. Certain Oxisols, the Acrorthox, have in the field a very weak subangular blocky structure which breaks into fine crumb. These crumbs are water stable aggregates and are alumino-silicate clays cemented by sesquioxides. The related distribution of such soil materials is agglutinic. The aggregates — there is practically no silt or sand — sometimes have a rim of oriented clay (ooidsepic plasmic fabric), subcutanic to the aggregate.

In fig. 1, this SRDP is confined to the region AOB but is best expressed in materials with plasmic NRDP or intergrades. The degree of expression of this SRDP is a function of the nature of the plasma — amount of sesquioxides — and the dessication of the soil. In an Acrorthox, agglutunic SRDP is present in the upper part of the profile; in the middle part, the aggregates are present but are coalesed whilst in the lower part the RDP is plasmic.

Reticulic

The reticulic SRDP is one where the plasma is arranged in a reticulate pattern. The plasma may incorporate silt and fine sand grains. This SRDP is rare.

Complete plasmafication of a vesicular basalt or granite without collapse of the material results in this SRDP. Formation of this SRDP is confined to the saprolite zone of weathering (Plate 2, c).

In some cases, two distinct kinds of plasma — kaolinite and sesquioxides — in a plasmic to porphyric NRDP may show this. The sesquioxidic plasma attains a reticulate pattern (Plate 2, d). This feature is common in the mottled zone of deep weathering profiles in the humic tropics. In this case a reticulic SRDP is superimposed on a plasmic NRDP.

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SUMMARY

Related distribution patterns are important micromorphological parameters for pedogenetical studies. Two groups are recognised, a normal (basic) related distribution pattern and a specific related distribution pattern, depending on the role of plasma. Within each group several types are evaluated. Relation between granulometric data and basic related distribution patterns is studied in triangle diagram. Each of the types is defined; some are illustrated and examples of the soils where they occur is given.

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